ECOSYSTEM STATUS INDICATORS

Ecosystem or Community Indicators

Combined Standardized Indices of recruitment and survival rate

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Description of indices: This section provides indices of overall recruitment and survival rate (adjusted for spawner abundance) across the major commercial groundfish species in the Eastern Bering Sea / Aleutian Islands (BSAI, 11 stocks) and Gulf of Alaska (GoA, 11 stocks, dusky rockfish was added this year). Time series of recruitment and spawning biomass for demersal fish stocks were obtained from the 2004 SAFE reports (NPFMC 2004a and b). Survival rate (SR) indices for each stock were computed as residuals from a spawner-recruit model. Both a Ricker and Beverton-Holt model (with or without first-order autocorrelated errors) were fit to each stock's recruitment and female spawning biomass data and the model with the best fit (based on the small-sample Akaike Information Criterion) was used to compute the SR index. Each time series of recruitment or SR indices was standardized to have a mean of 0 and a standard deviation of 1 (hence giving equal weight to each stock in the combined index, see below). Recruitment or SR series were lined up by year-class, resulting in matrices of recruitment / SR indices by year with missing values at the beginning and end of many series. A combined standardized index of recruitment (CSI_R) and survival (CSI_{SR}) was computed by simply averaging indices within a given year across stocks. Prior to standardizing the series, missing values in each series were estimated by imputation using additive regression, bootstrapping, and predictive mean matching as implemented in the "hmisc" package for S-Plus (Frank Harrell, Univ. of Virginia, pers. comm.). Multiple imputations were obtained by bootstrap resampling to estimate the variability in the averaged index that results from filling in missing values. Uncertainty in the stock-specific estimates of R and SR was not accounted for.

Status and trends: The CSI_R suggests that recruitment of demersal species in the GoA and BSAI followed a similar pattern with mostly above-average recruitments from the mid- or late 1970s to the late 1980s, followed by below-average recruitments during the early 1990s (GoA) or most of the 1990s (BSAI) (Figure 106). Estimates at the beginning and end of the series were based on only a few stocks and are highly uncertain, but recruitment in the BSAI remained mostly below average through 2003, the last year for which data for at least 3 stocks was available. Recruitment indices for the GoA indicated variable recruitment through the 1990s and below average recruitment in 2001 and 2002. The CSI_{SR} were more variable but showed very similar patterns. Both regions had unusually high survival and recruitment indices in 1984, when recruitment of all stocks except flathead sole in the GoA and yellowfin sole in the BSAI were estimated to be above average.

Factors causing trends: Trends in recruitment are a function of both spawner biomass and environmental variability. Trends in survival rate indices, which are adjusted for differences in spawner biomass, are presumably driven by environmental variability but are even more uncertain than recruitment trends. Typically, spawner biomass accounted for only a small proportion of the overall variability in estimated recruitment. The observed patterns in recruitment and survival suggest decadal-scale variations in overall groundfish productivity in the Gulf of Alaska and Bering Sea that are moderately to strongly correlated between the two regions (CSI_R: $r = 0.38$; CSI_{SR}: $r = 0.52$). These variations in productivity are correlated with and may in part be driven by variations in large-scale climate patterns such as the PDO, which changed sign in 1976/77, and the Victoria pattern, which changed sign in 1989/90. Recruitment and survival indices for the Gulf of Alaska (but not for the Bering

Sea) were significantly positively correlated with the Nov-Mar PDO index for the preceding winter (r = 0.56, $p < 0.001$ for CSI_R; r=0.36, p = 0.045 for CSI_{SR}).

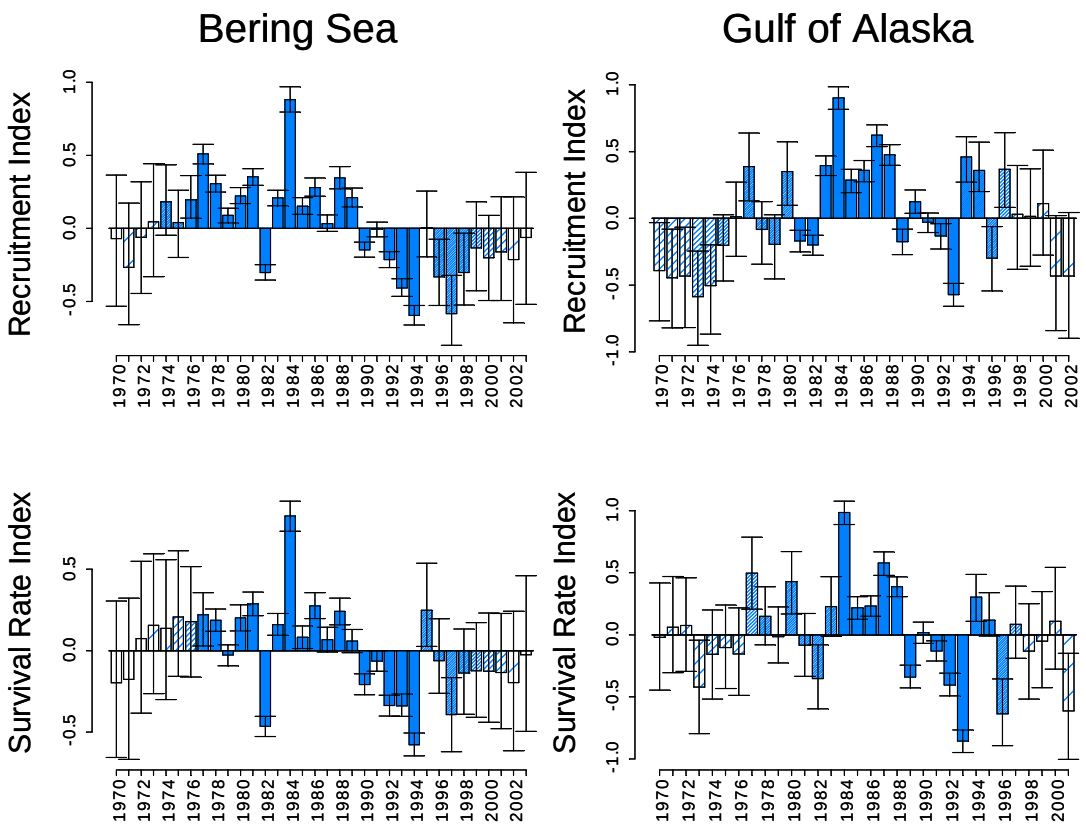

Figure 106. Combined Standardized Indices of recruitment (top) and survival rate (Ricker residuals, bottom) by year class across demersal stocks in the Bering Sea / Aleutian Island region (11 stocks) and in the Gulf of Alaska (11 stocks). Solid blue bars represent years with data for all stocks or stock groups. Lighter shading corresponds to years with more missing stocks. Series were truncated in 1970 and only years with data for at least 3 stocks were included. Bootstrap confidence intervals (95%) depict uncertainty resulting from filling in missing values but assume that survival and recruitment are estimated without error.